

Salt Tolerance of Crops in the Lower San Joaquin River (Stanislaus to Merced River Reaches) Presentation of Draft Report

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Overview

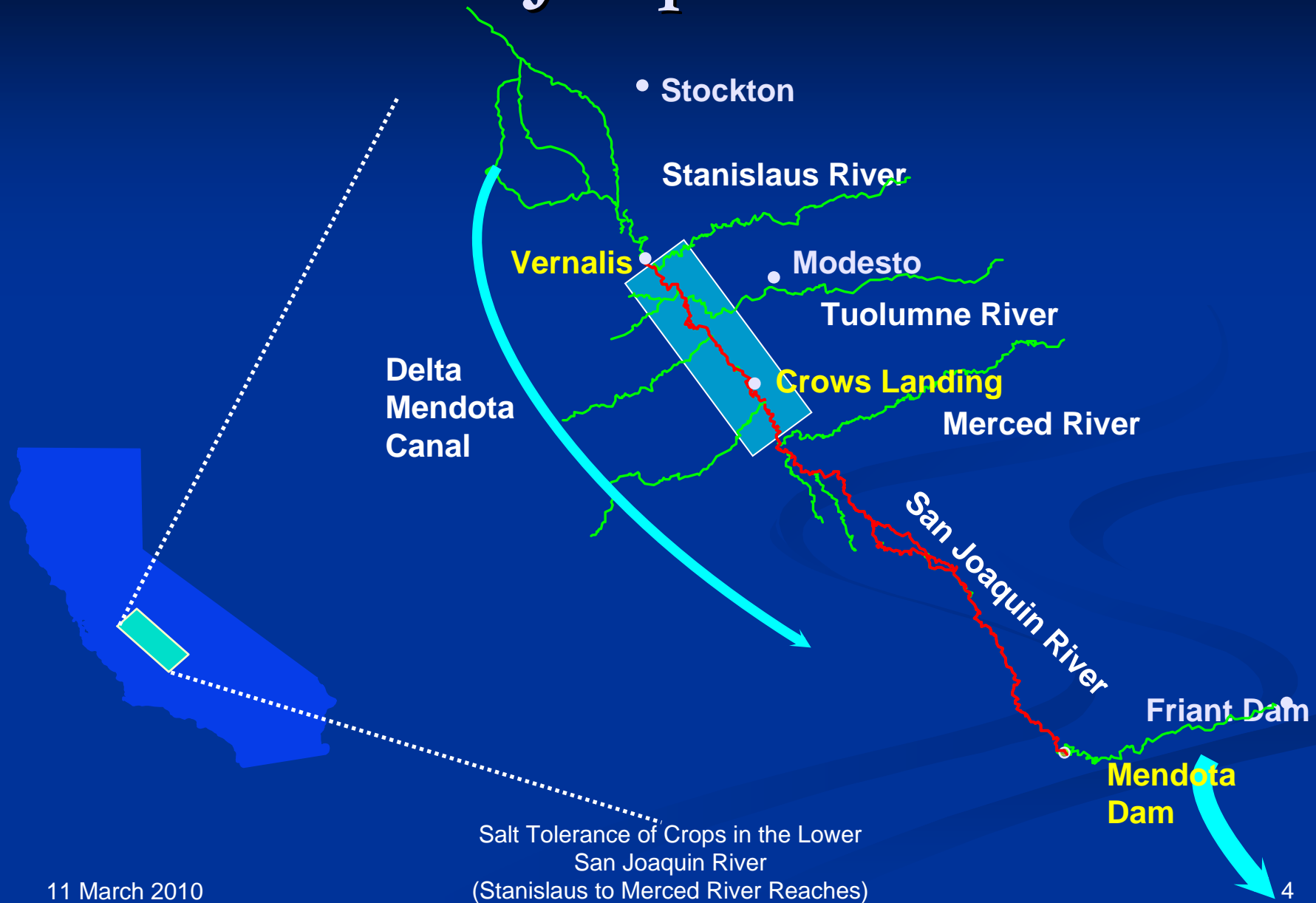
- San Joaquin River Upstream Salt and Boron Basin Plan Amendment (BPA)
- Salt Tolerance of Crops in the Lower San Joaquin River (LSJR)
- Comment Period

Why is a Basin Plan Amendment needed?

- SJR water quality degradation recognized in 1975 Basin Plan
- 303(d) listing in 1998 for both salt and boron
- Water Rights Decision 1641
- Second phase of SJR Salt and Boron TMDL

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Lower San Joaquin River Basin



11 March 2010

Beneficial Uses

	MUN	AGR		PROC	REC 1		REC 2	W A R M	C O L D	MIGR		SPWN		WILD
	Municipal and Domestic Supply	Irrigation	Stock Watering	Industrial Process Supply	Contact	Canoeing and Rafting	Other Noncontact	Freshwater Habitat-Warm	Freshwater Habitat-Cold	Warm	Cold	Warm	Cold	Wildlife Habitat
Lower SJR (Stanislaus River to Merced River)	P	E	E	E	E	E	E	E		E	E	E		E

P = Potential E = Existing

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Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta

Dr. Glenn J. Hoffman

5 January 2010

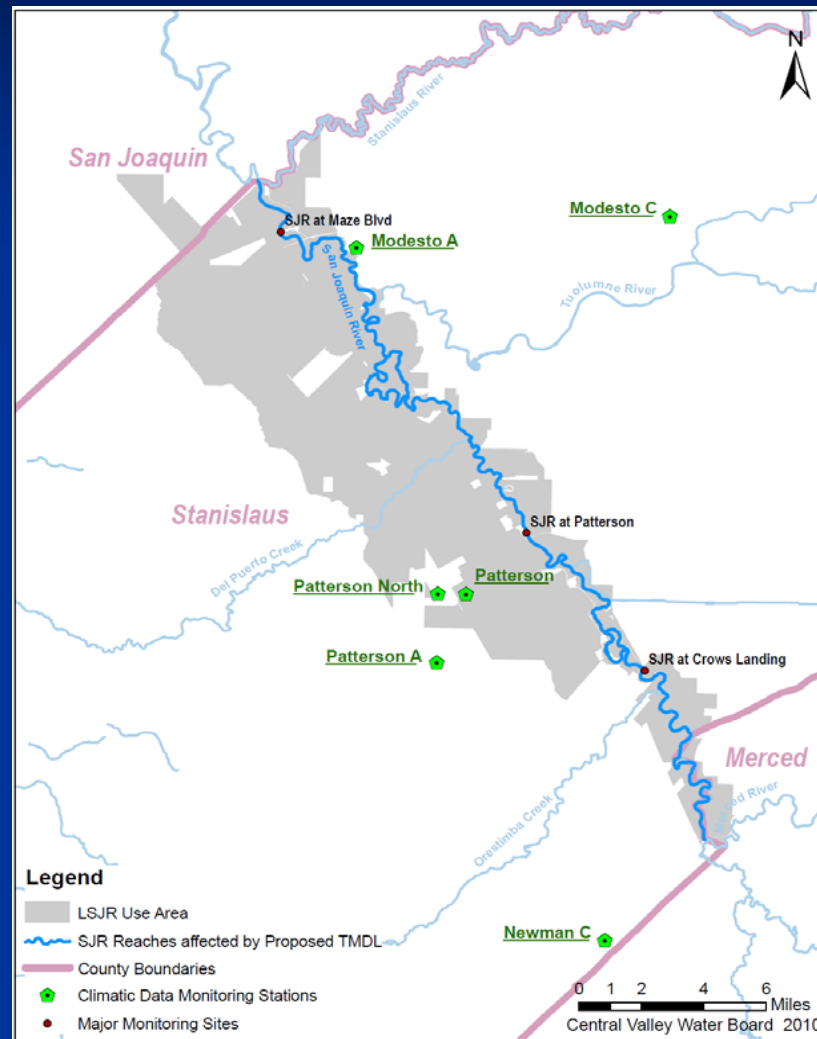
http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/bay_delta_plan/water_quality_control_planning/

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Objectives

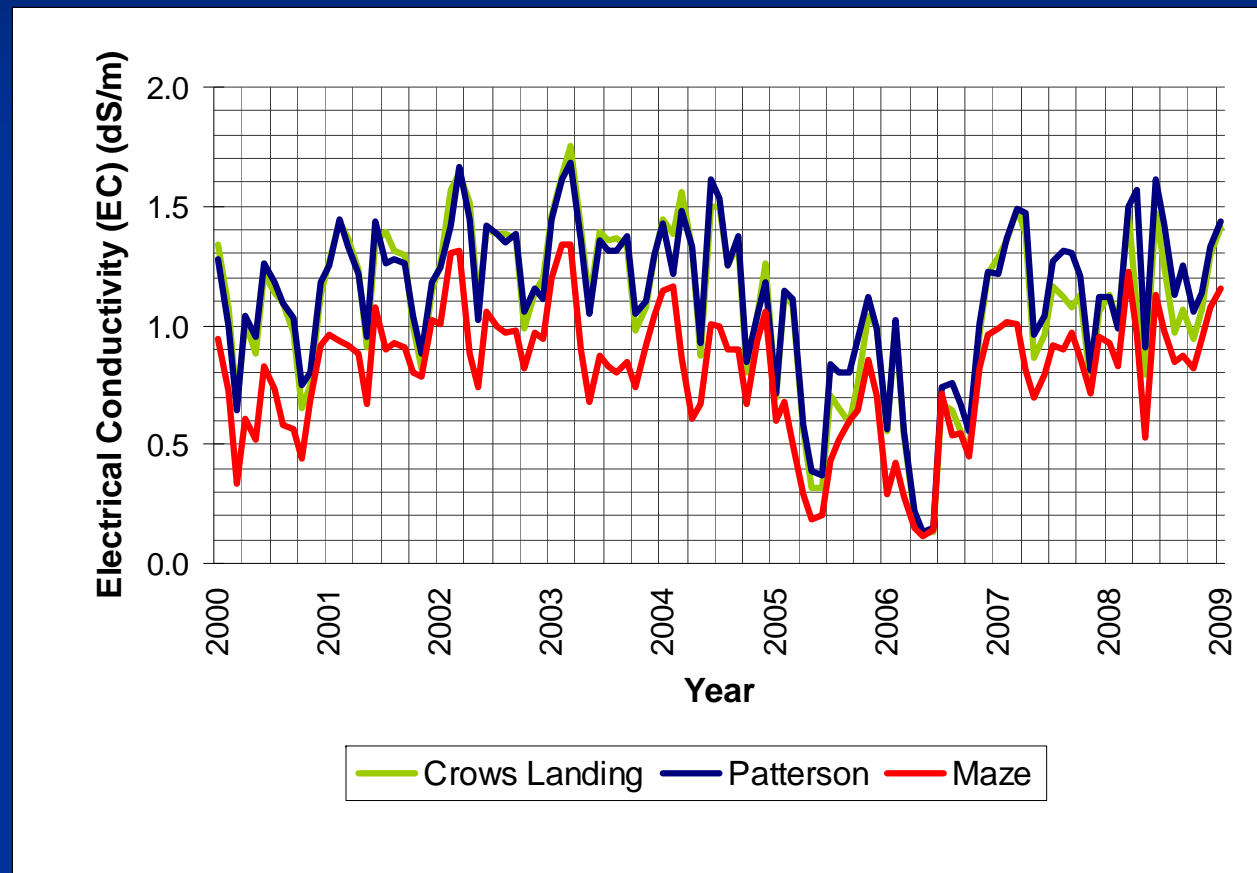
- Consider relevant science/literature on the subject
- Compile appropriate data
 - Water quality
 - Geographic
 - Land use
- Apply steady-state soil salinity model
- Use steady-state model to identify potential thresholds to protect agricultural (irrigation) beneficial use

LSJR Irrigation Use Area



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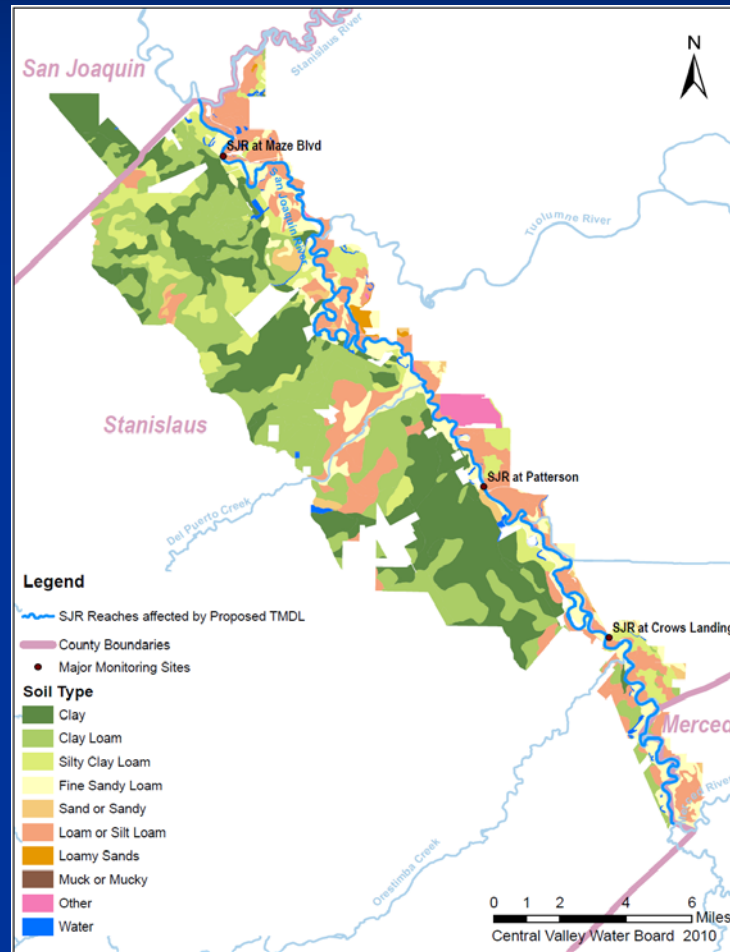
Lower San Joaquin River Salinity



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LSJR Irrigation Use Area

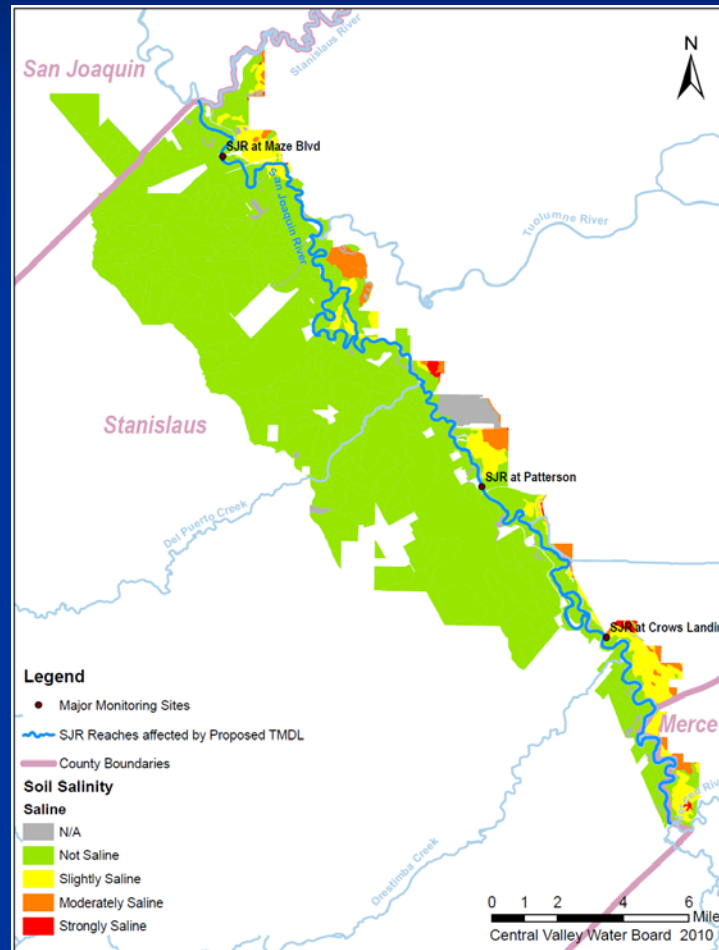
Soil Types



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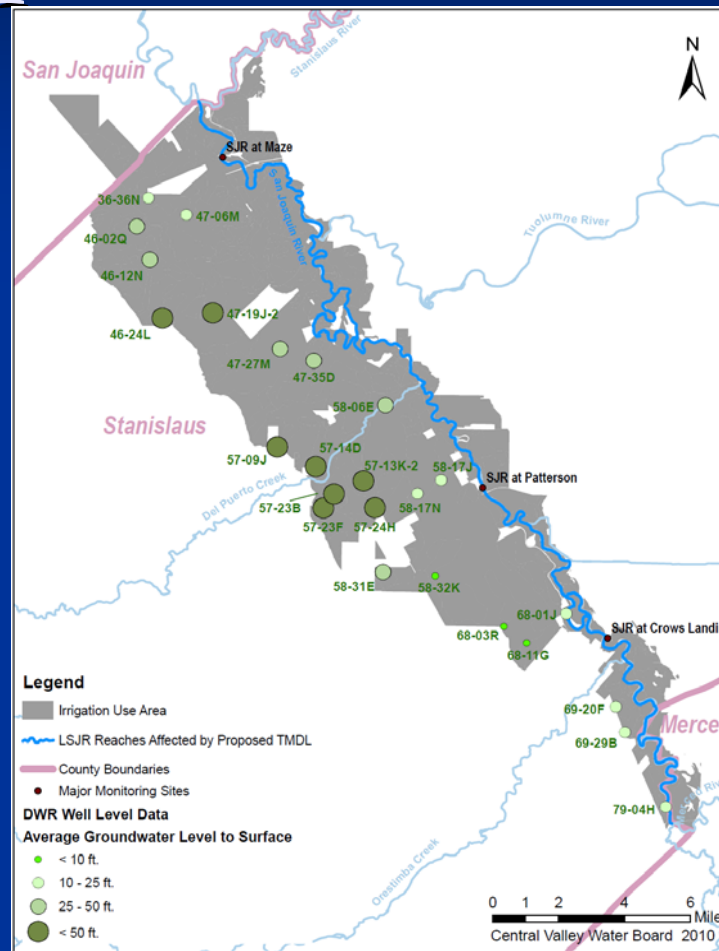
LSJR Irrigation Use Area

Saline Soils



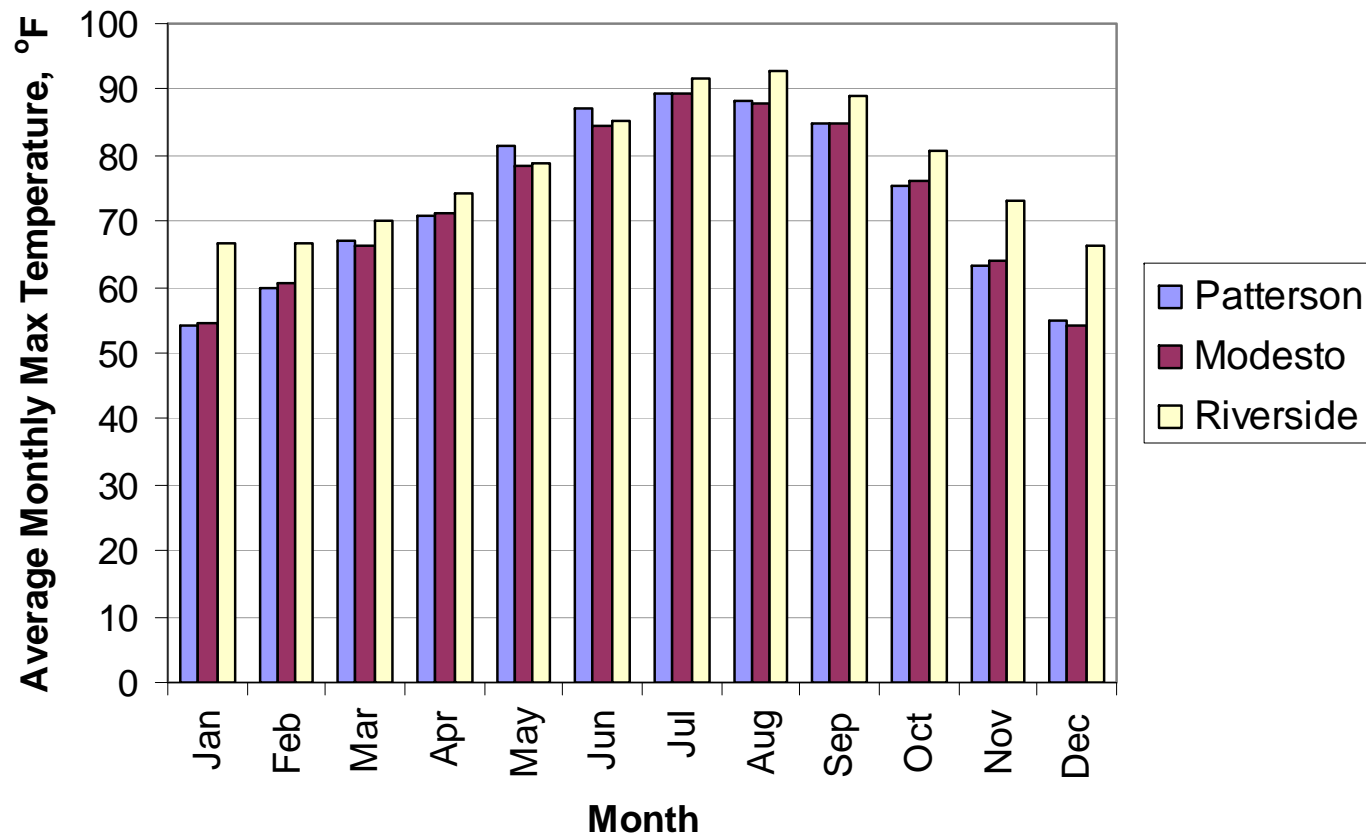
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LSJR Irrigation Use Area Depth to Groundwater



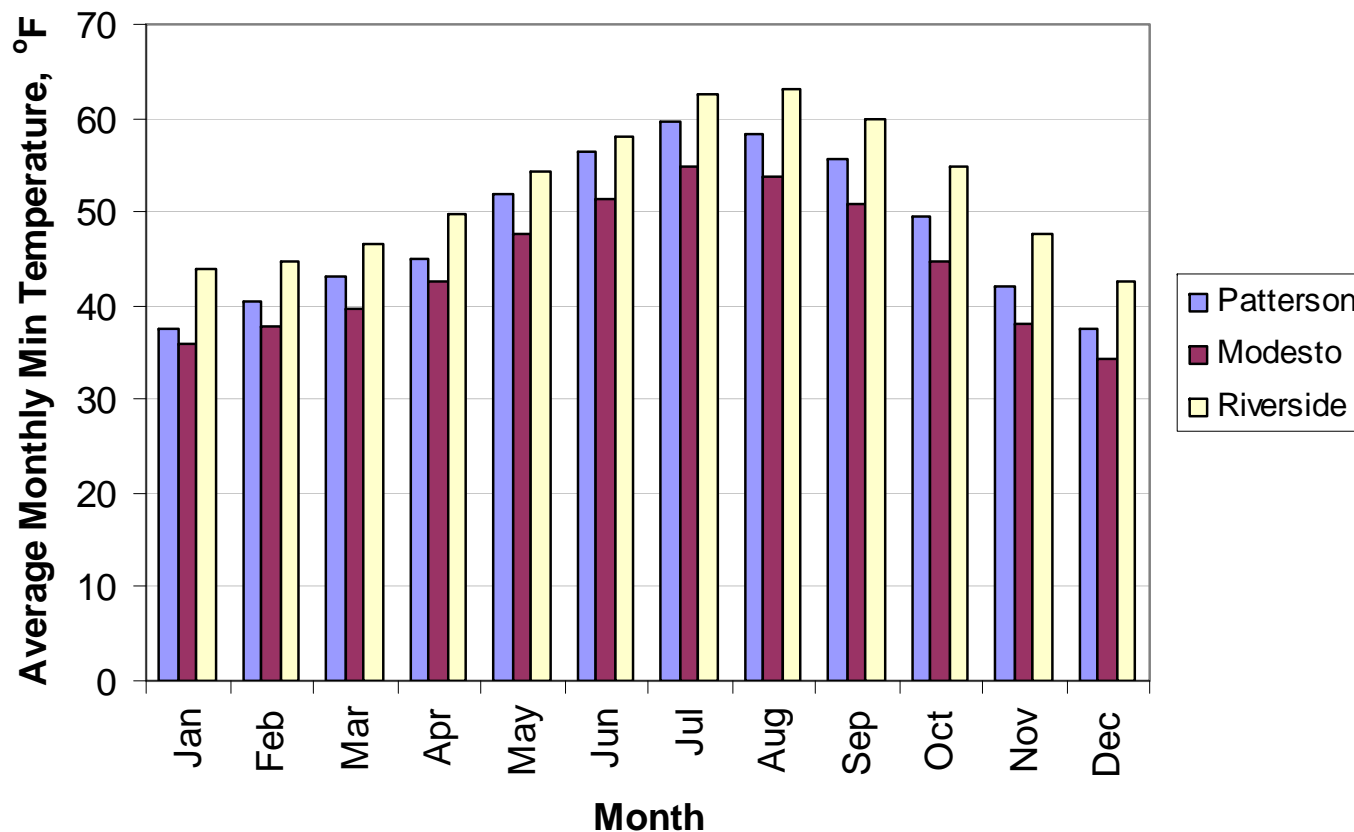
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Average Monthly Maximum Temperature



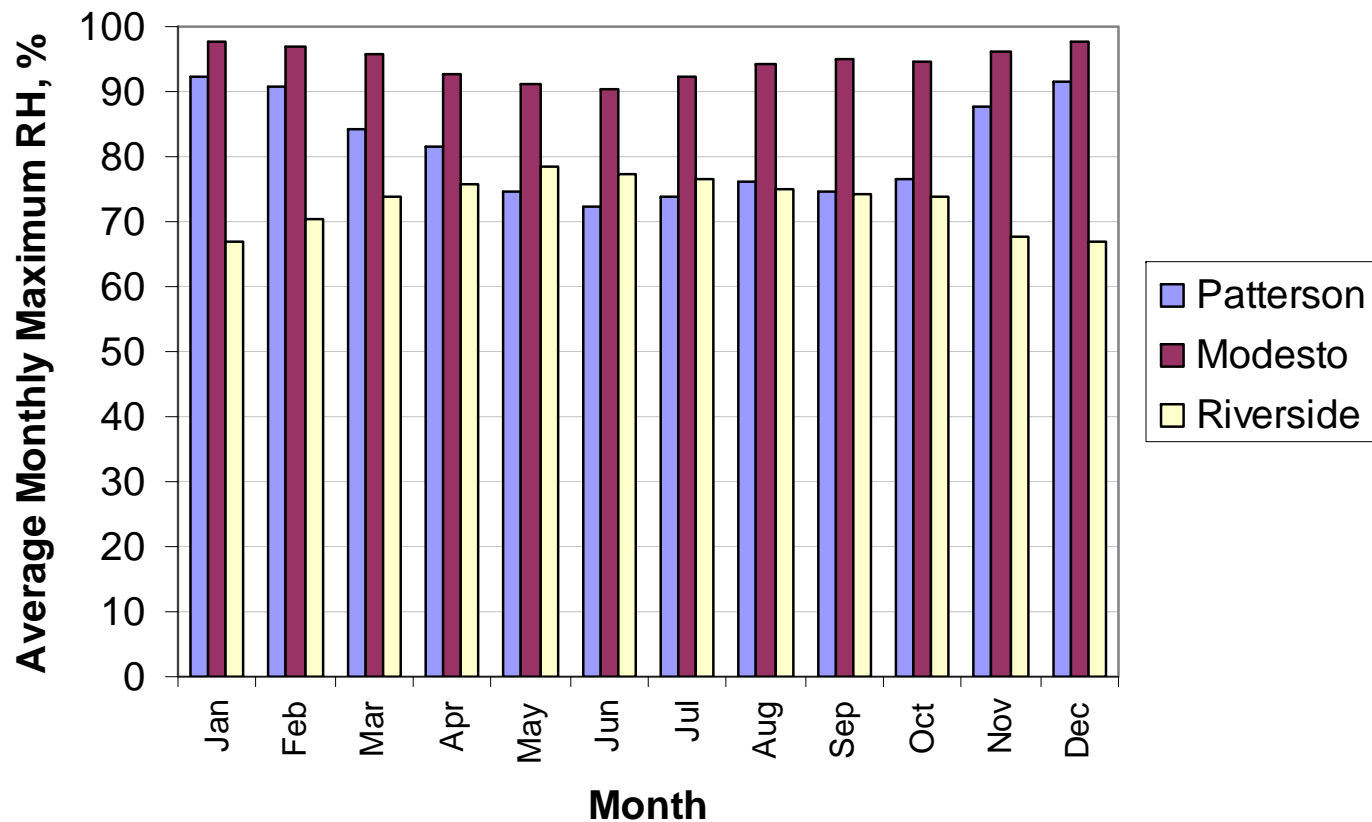
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Average Monthly Minimum Temperature



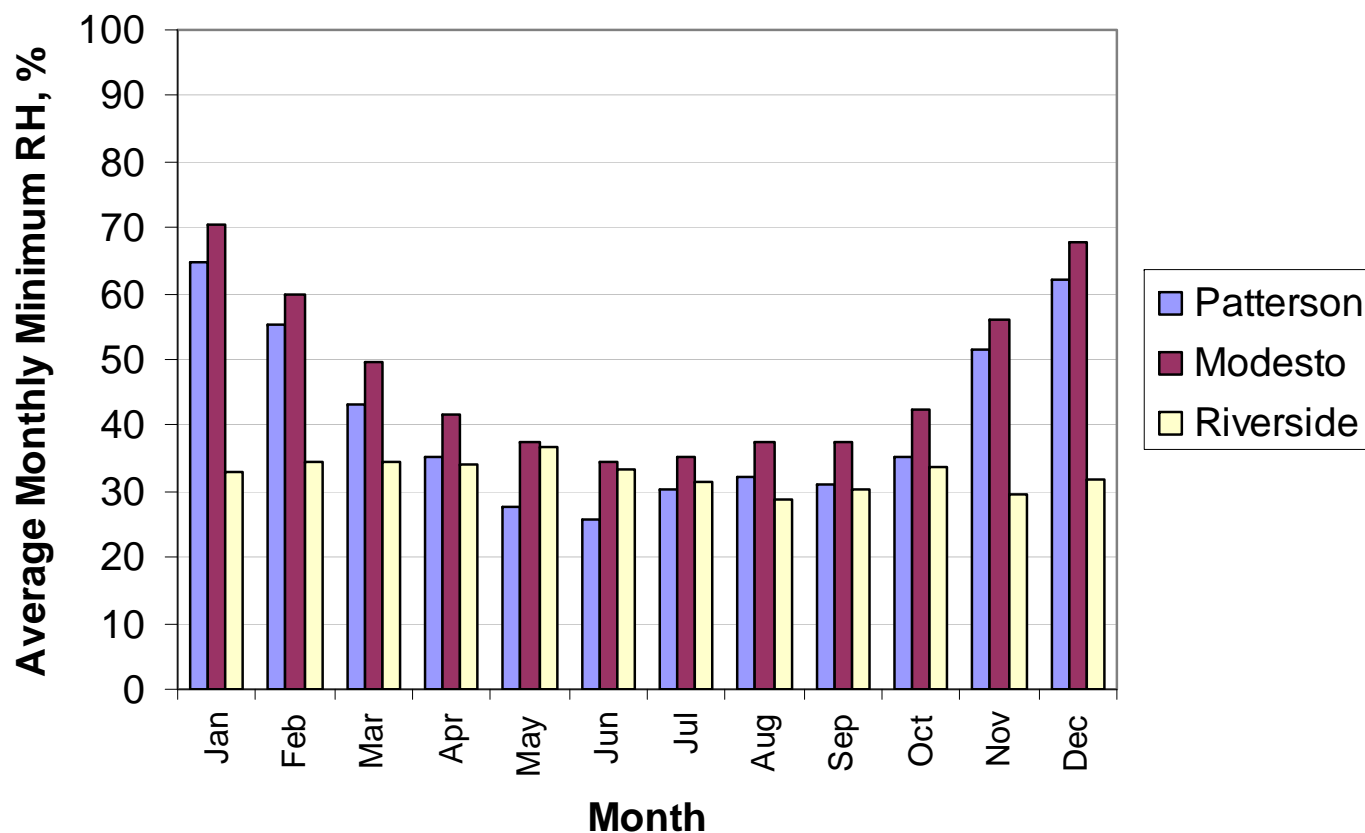
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Average Monthly Maximum Relative Humidity



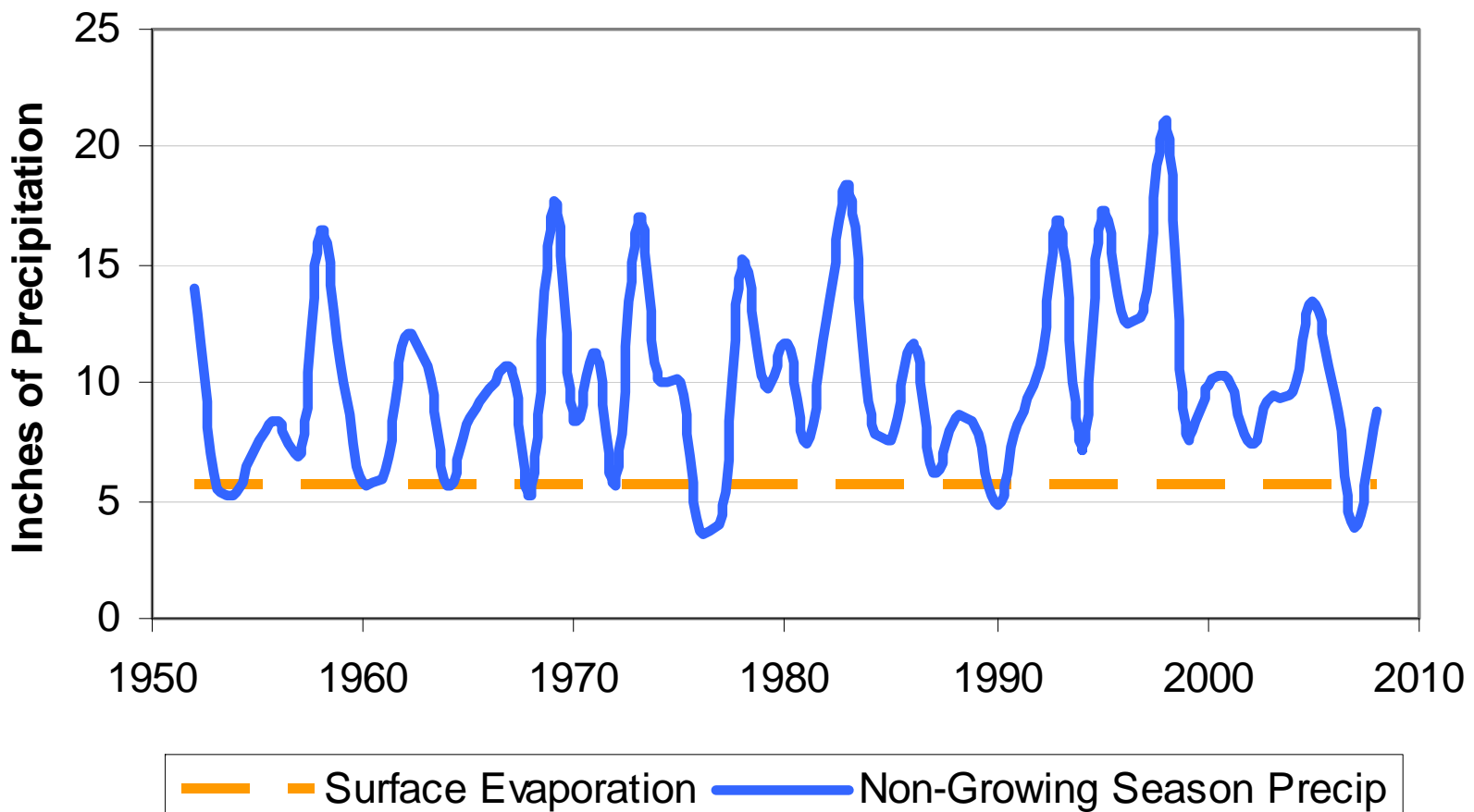
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Average Monthly Minimum Relative Humidity



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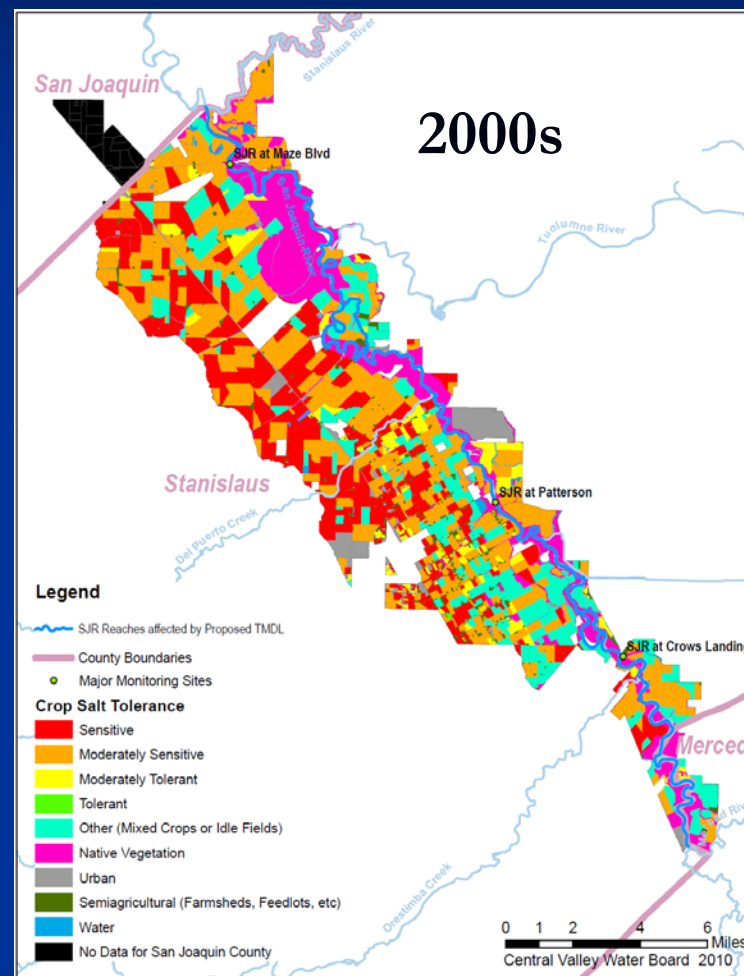
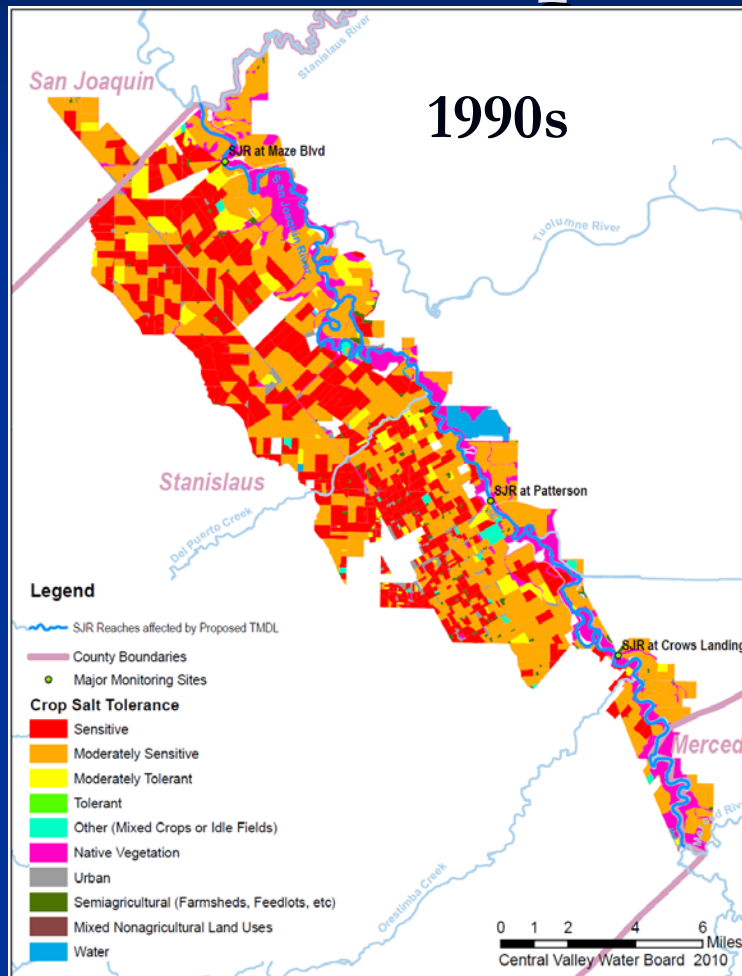
Non-Growing Season Precipitation



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LSJR Irrigation Use Area

Crop Distribution



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Proportions of Dry Beans

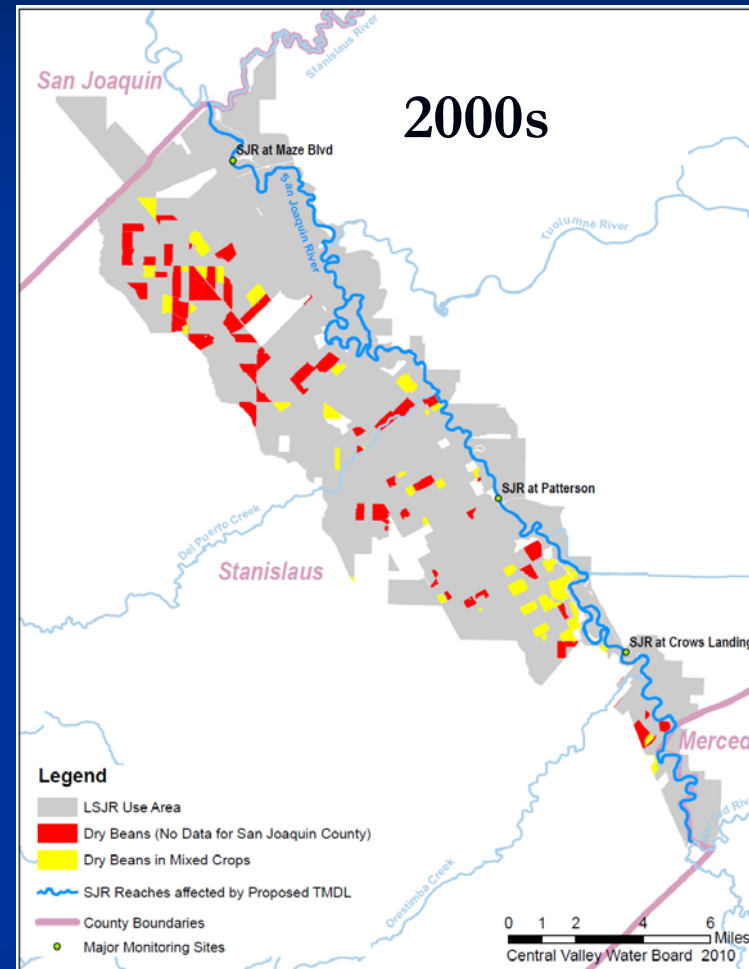
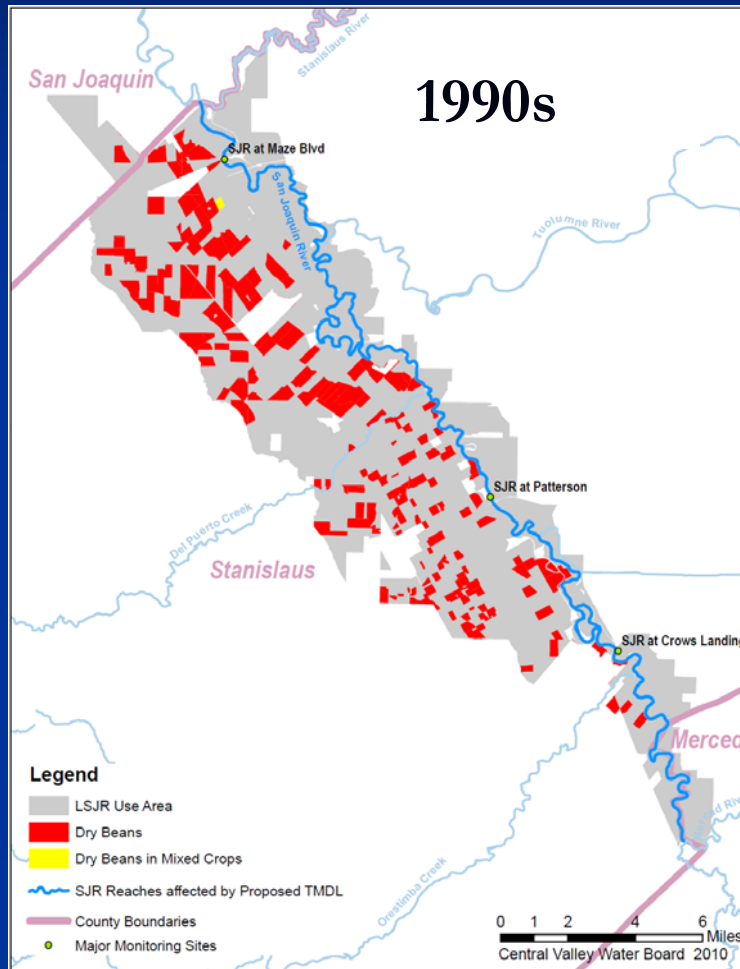
1990s and 2000s

Crop	Threshold* ECe, dS/m	Relative Tolerance	DWR Irrigated Acreage
Alfalfa	2.0	MS	9398
Almond	1.5	S	4343
Apricot	1.6	S	2776
Bean (Dry)	1.0	S	5893
Cabbage	1.8	MS	606
Castor Bean	---	MS	3019
Celery	1.8	MS	7455
Grape	1.5	MS	512
Sudan Grass	2.8	MT	613
Walnut	---	S	2338

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Distribution of Dry Beans



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Steady State Modeling for LSJR

- Steady state assumption
 - Mass balance approach ($I + P = ET_c + D$)
 - One dimensional
- Crop evapotranspiration
 - Used Hargreaves equation
 - Crop coefficients
- Cropping assumptions
 - 3 crops selected: Bean, Alfalfa and Almond
 - All 3 crops have specific planting dates

Crop Growth Cycles

■ Bean

- Assumed three planting dates
- Growth cycle is about 4 months

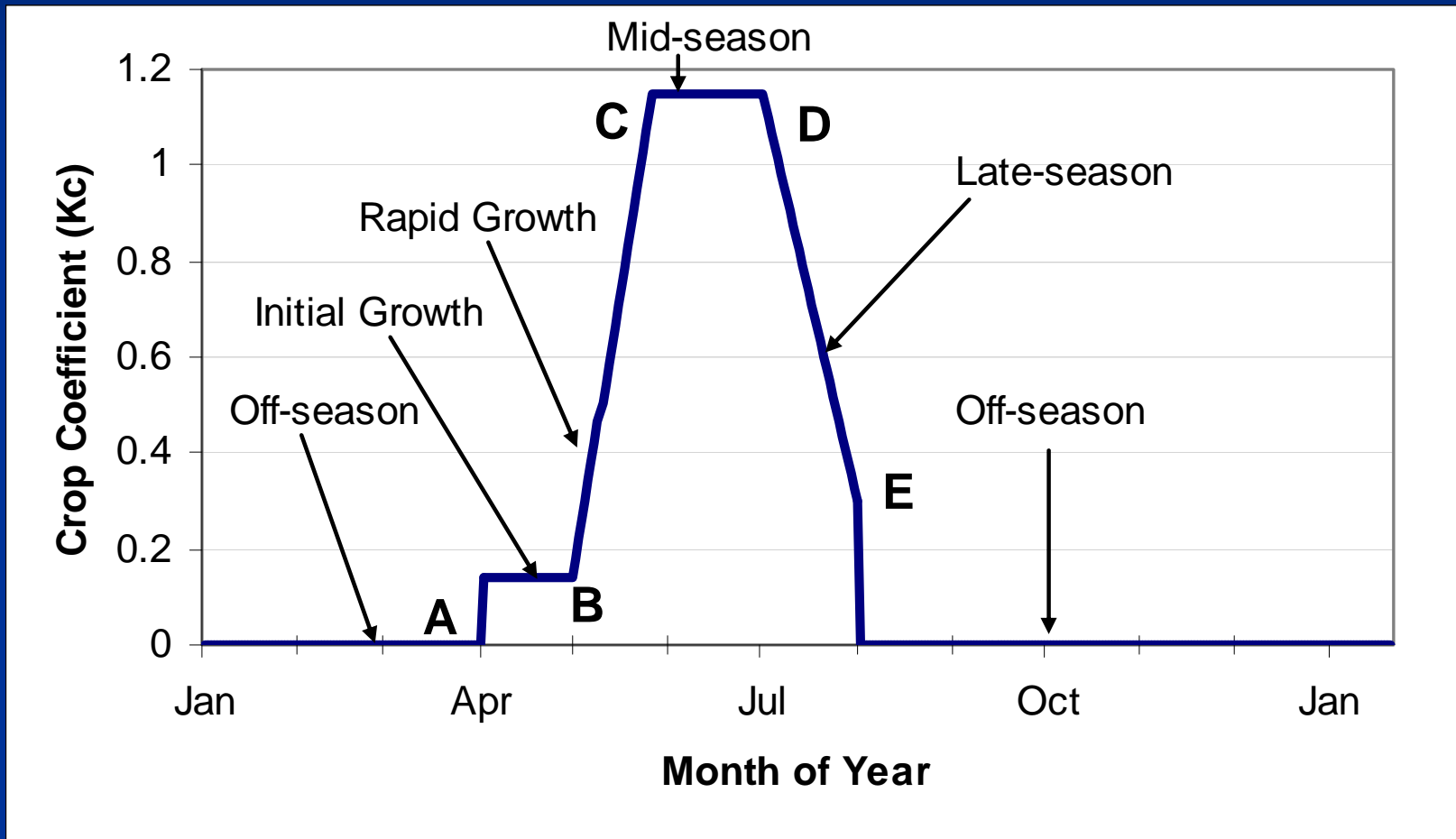
■ Alfalfa

- Goes through about 7 cutting cycles
- Growth cycle is about 28-30 days

■ Almond

- Managed as an orchard
- Assumed no cover crop on orchard floor

Bean Growth Stages



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Variation of Bean Planting Date

April 1st Planting Date

<u>Growth Stage</u>	<u>Crop Coefficient (Kc)</u>	<u>Dates</u>
Initial Growth	0.14	April 1 to 30
Rapid Growth	0.14 to 0.15	April 30 to May 25
Mid-Season	1.15	May 25 to June 29
Late-Season	1.15 to 0.30	June 29 to July 31
121 Days Total		

Median EC_{swb-2}

<u>Crows Landing & Patterson</u>	L=0.15	L=0.20	L=0.25
EC _i = 0.7 dS/m	1.4	0.98	0.69
EC _i = 1.0 dS/m	2	1.4	0.99
<u>Maze</u>	L=0.15	L=0.20	L=0.25
EC _i = 0.7 dS/m	1.36	0.95	0.67
EC _i = 1.0 dS/m	1.94	1.35	0.96

May 1st Planting Date

<u>Growth Stage</u>	<u>Crop Coefficient (Kc)</u>	<u>Dates</u>
Initial Growth	0.14	May 1 to 18
Rapid Growth	0.14 to 1.12	May 18 to June 8
Mid-Season	1.12	June 8 to July 12
Late-Season	1.12 to 0.35	July 12 to August 15
106 Days Total		

Median EC_{swb-2}

<u>Crows Landing & Patterson</u>	L=0.15	L=0.20	L=0.25
EC _i = 0.7 dS/m	1.41	0.99	0.7
EC _i = 1.0 dS/m	2.02	1.41	0.99
<u>Maze</u>	L=0.15	L=0.20	L=0.25
EC _i = 0.7 dS/m	1.37	0.96	0.68
EC _i = 1.0 dS/m	1.96	1.37	0.97

June 16th Planting Date

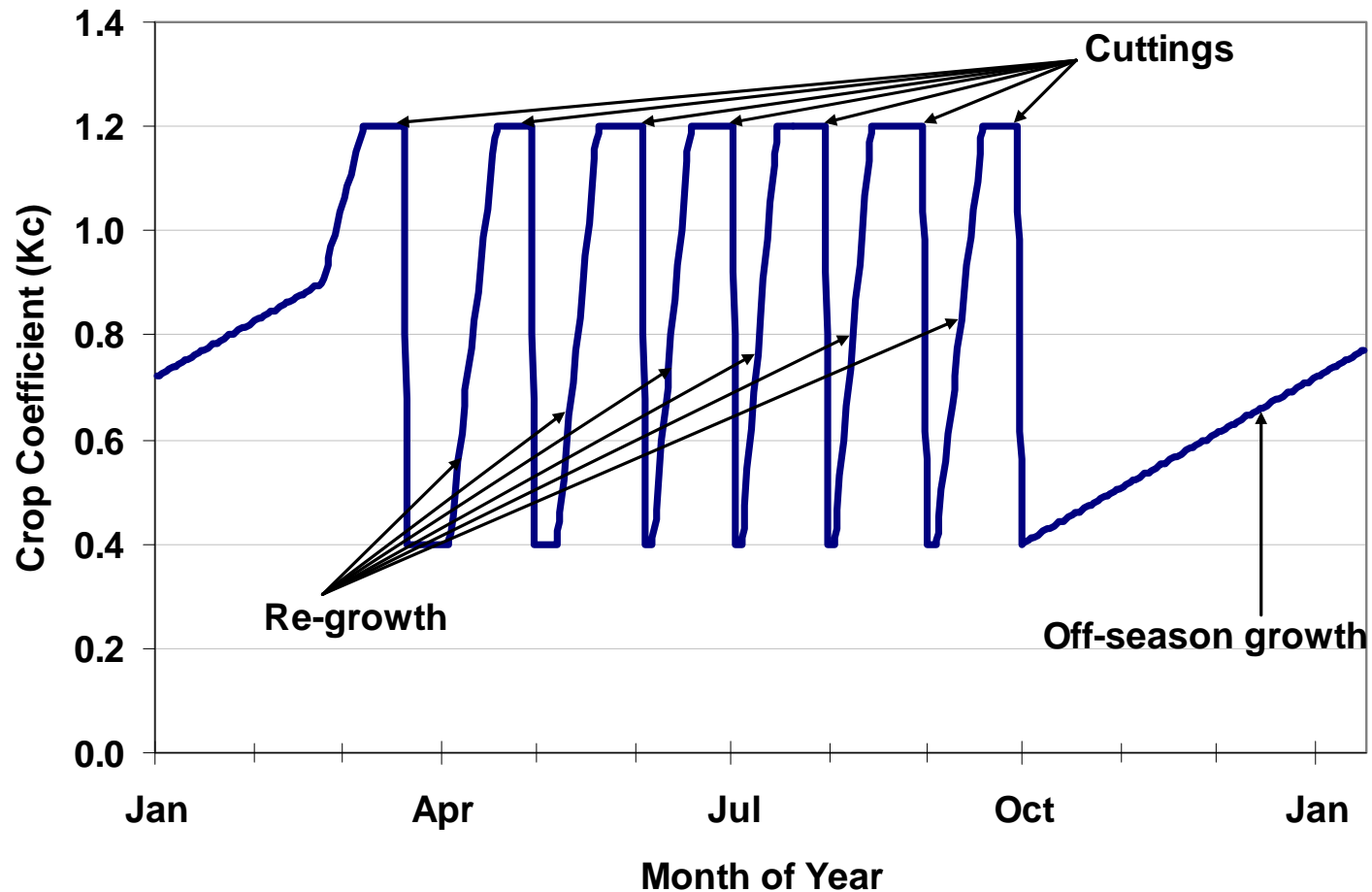
<u>Growth Stage</u>	<u>Crop Coefficient (Kc)</u>	<u>Dates</u>
Initial Growth	0.13	June 16 to July 1
Rapid Growth	0.13 to 1.07	July 1 to July 26
Mid-Season	1.07	July 26 to Sept. 2
Late-Season	1.07 to 0.20	Sept. 2 to Sept. 30
106 Days Total		

Median EC_{swb-2}

<u>Crows Landing & Patterson</u>	L=0.15	L=0.20	L=0.25
EC _i = 0.7 dS/m	1.36	0.95	0.68
EC _i = 1.0 dS/m	1.95	1.36	0.96
<u>Maze</u>	L=0.15	L=0.20	L=0.25
EC _i = 0.7 dS/m	1.33	0.93	0.66
EC _i = 1.0 dS/m	1.9	1.33	0.95

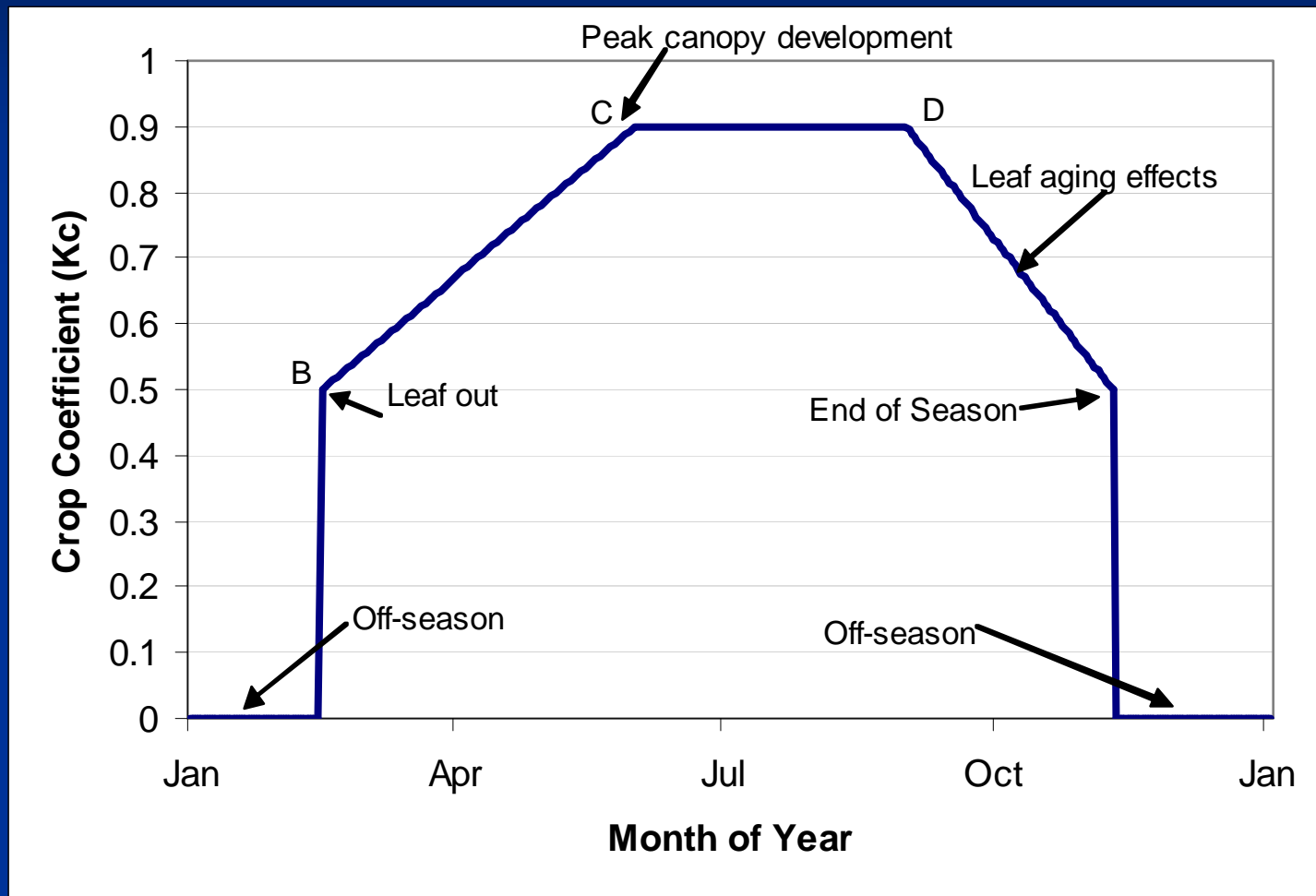
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Alfalfa growth cycle



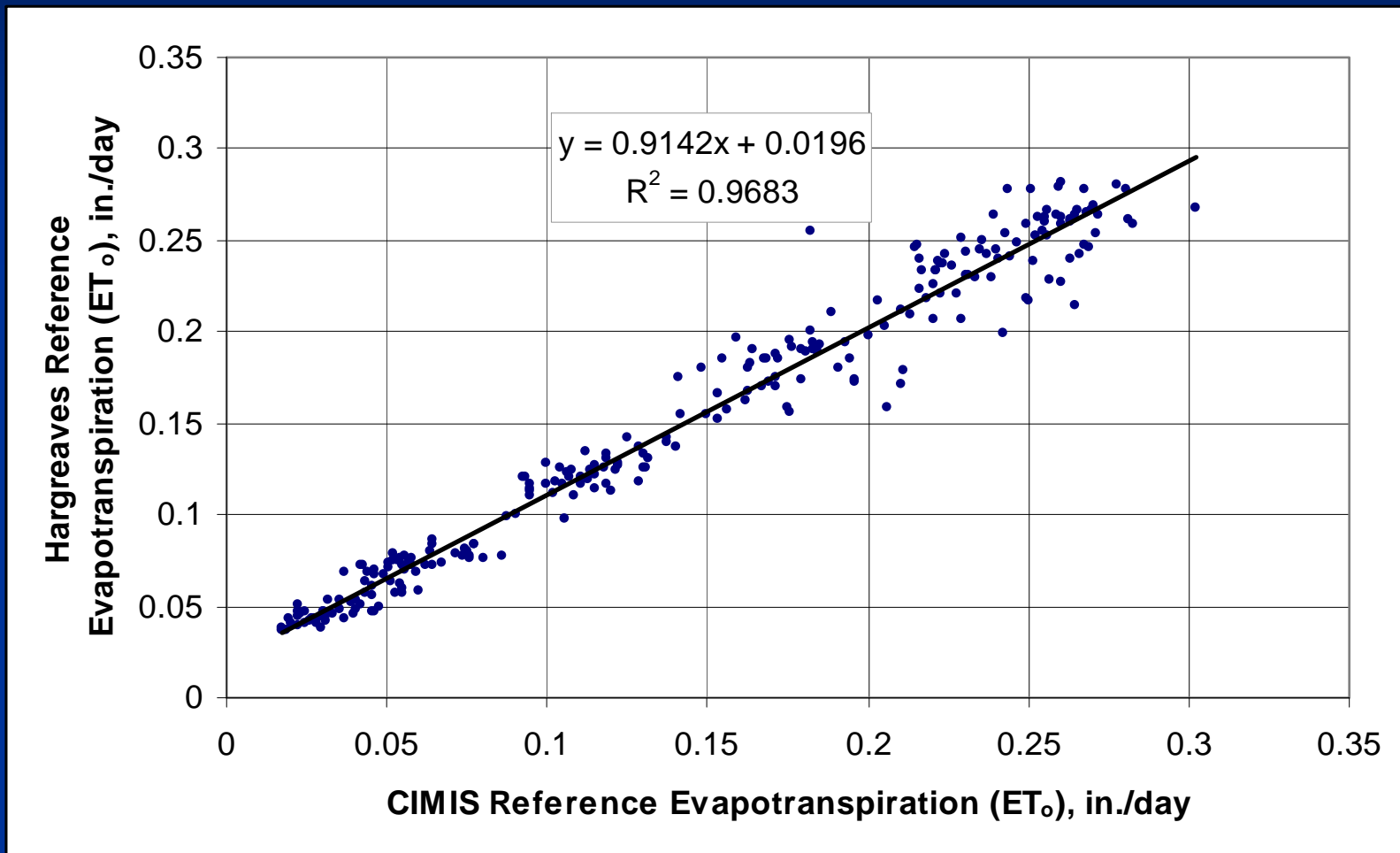
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Almond growth cycle



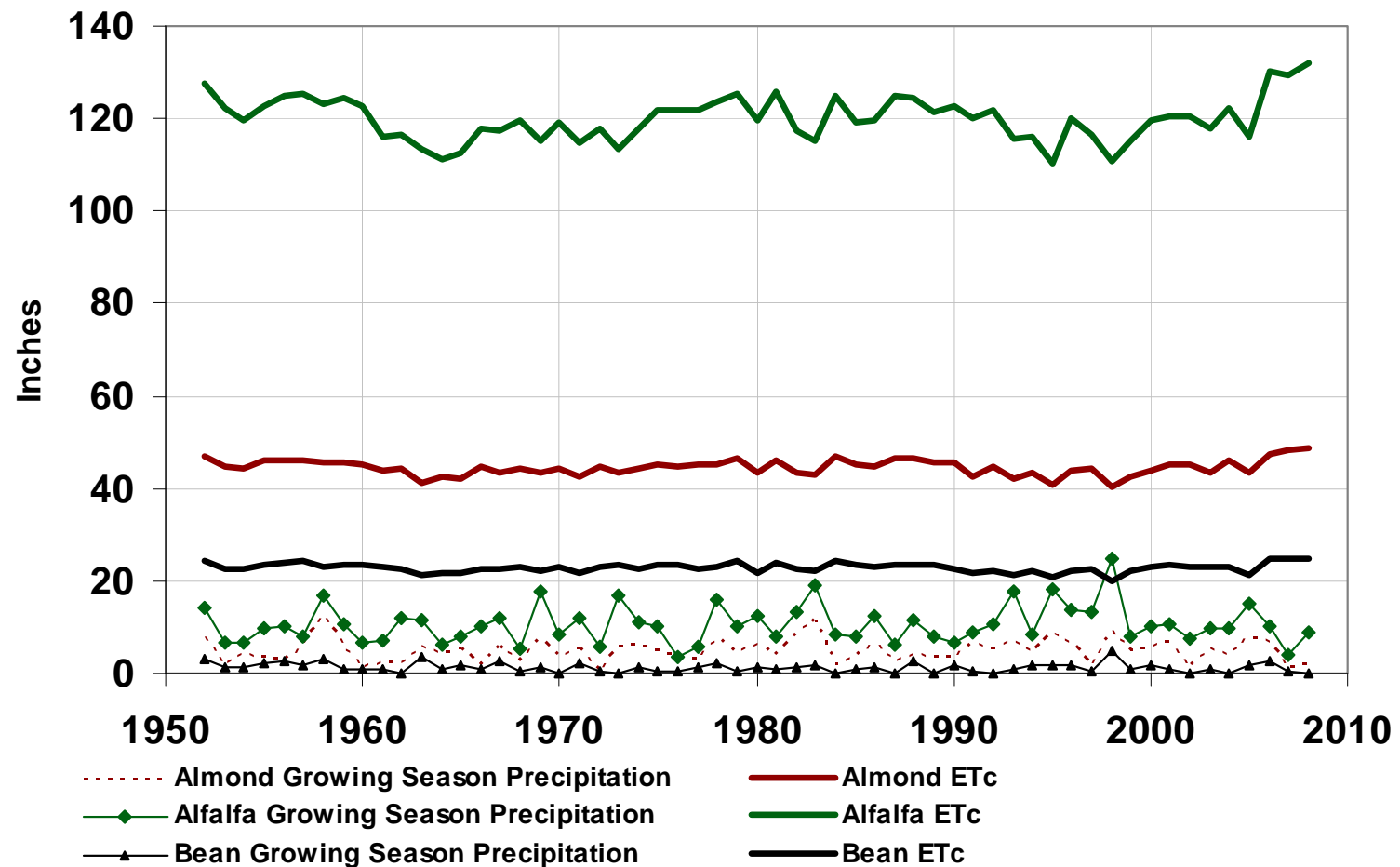
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Crop Evapotranspiration



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Precipitation



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Model Output for Dry Beans

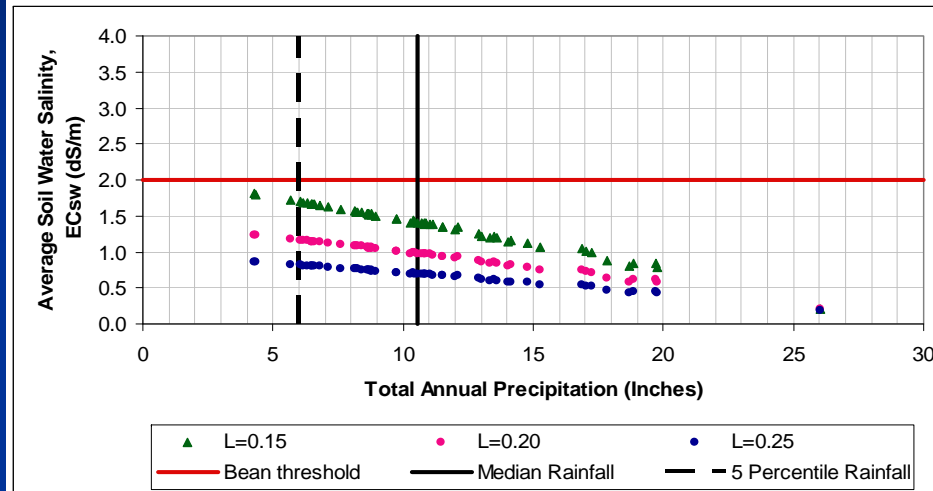
Input Variables							Model Output						
<div>EC_i = 1.0</div> <div>LF = 0.15</div>													
Water Year	ET _C = crop evapotranspiration E _s = off-season surface evaporation P _{GS} = precipitation during growing season P _T = total annual (infiltrating) precipitation						1) Without precipitation LF = Leaching fraction EC _i = irrigation water salinity I ₁ = Irrigation requirement EC _{SWa-1} = Av'ge soil water EC			2) With precipitation I ₂ = Irrigation required for LF ₂			
	P _T (in.)	P _{NG} (in.)	E _S (in.)	P _{GS} (in.)	P _{EFF} (in.)	ET _C (in.)	I ₁ (in.)	EC _{SWa-1} (dS/m)	EC _{SWb-1} (dS/m)	I ₂ (in.)	EC _{AW-2} (dS/m)	EC _{SWa-2} (dS/m)	EC _{SWb-2} (dS/m)
1952	16.9	16.9	6.0	0.0	10.9	23.5	27.6	3.18	2.46	16.67	0.60	1.92	1.41
1953	6.8	6.8	5.9	0.0	0.8	22.3	26.3	3.18	2.46	25.43	0.97	3.08	2.38
1954	6.5	6.5	5.9	0.0	0.6	22.3	26.3	3.18	2.46	25.70	0.98	3.11	2.41
1955	9.8	9.0	5.9	0.8	3.8	22.9	26.9	3.18	2.46	23.14	0.86	2.73	2.11
1956	10.9	10.1	6.0	0.8	4.9	23.3	27.4	3.18	2.46	22.52	0.82	2.61	2.02
1957	8.7	7.8	5.9	0.9	2.7	23.9	28.1	3.18	2.46	25.33	0.90	2.87	2.22
1958	19.7	18.6	5.9	1.1	13.8	22.8	26.8	3.18	2.46	13.08	0.49	1.55	1.21
1959	10.8	10.8	5.9	0.0	4.9	23.2	27.3	3.18	2.46	22.43	0.82	2.61	2.02
1960	6.6	6.6	6.0	0.0	0.6	23.3	27.5	3.18	2.46	26.80	0.98	3.11	2.40
1961	7.1	6.6	5.9	0.6	1.2	23.1	27.2	3.18	2.46	26.03	0.96	3.04	2.36
1962	12.0	12.0	5.9	0.0	6.1	22.3	26.2	3.18	2.46	20.12	0.77	2.44	1.89
1963	14.0	13.8	5.9	0.2	8.1	21.2	25.0	3.18	2.46	16.89	0.68	2.15	1.67
1964	6.5	5.9	6.0	0.6	0.5	21.4	25.1	3.18	2.46	24.63	0.98	3.12	2.41
1965	10.3	9.9	5.9	0.4	4.3	21.2	24.9	3.18	2.46	20.60	0.83	2.63	2.02
1966	10.6	10.2	5.9	0.4	4.6	22.1	26.0	3.18	2.46	21.32	0.82	2.61	2.02
1967	13.5	13.2	5.9	0.3	7.5	22.5	26.4	3.18	2.46	18.88	0.71	2.27	1.76
1968	6.1	6.0	6.0	0.0	0.1	22.6	26.6	3.18	2.46	26.52	1.00	3.17	2.45
1969	18.8	18.8	5.9	0.0	12.9	21.6	25.4	3.18	2.46	12.48	0.49	1.56	1.21
1970	8.6	8.6	5.9	0.1	2.7	22.5	26.5	3.18	2.46	23.75	0.90	2.86	2.22
1971	13.4	12.7	5.9	0.6	7.4	21.8	25.7	3.18	2.46	18.26	0.71	2.26	1.77
1972	6.2	6.2	6.0	0.0	0.2	22.6	26.6	3.18	2.46	26.37	0.99	3.16	2.44
1973	17.0	17.0	5.9	0.0	11.1	22.7	26.7	3.18	2.46	15.61	0.59	1.86	1.41
1974	11.5	10.8	5.9	0.7	5.6	22.2	26.1	3.18	2.46	20.49	0.79	2.50	1.93
1975	10.7	10.7	5.9	0.0	4.8	23.0	27.1	3.18	2.46	22.31	0.82	2.62	2.02
1976	4.3	4.3	6.0	0.0	-1.7	22.5	26.5	3.18	2.46	28.16	1.06	3.38	2.62
1977	5.7	5.2	5.9	0.5	-0.3	22.7	26.7	3.18	2.46	27.00	1.01	3.21	2.49
1978	17.3	17.2	5.9	0.0	11.3	23.0	27.1	3.18	2.46	15.77	0.58	1.85	1.41
1979	10.4	10.2	5.9	0.2	4.4	23.5	27.7	3.18	2.46	23.26	0.84	2.67	2.02
1980	13.0	12.5	6.0	0.6	7.1	21.9	25.8	3.18	2.46	18.71	0.73	2.31	1.79
1981	8.2	7.8	5.9	0.4	2.3	23.3	27.5	3.18	2.46	25.16	0.92	2.91	2.22
1982	14.8	14.7	5.9	0.1	8.9	22.0	25.9	3.18	2.46	17.04	0.66	2.09	1.62
1983	19.8	19.4	5.9	0.4	13.8	22.0	25.9	3.18	2.46	12.07	0.47	1.48	1.11
1984	8.4	8.4	6.0	0.0	2.5	23.8	28.0	3.18	2.46	25.53	0.91	2.90	2.22
1985	8.2	7.8	5.9	0.4	2.3	22.9	26.9	3.18	2.46	24.65	0.92	2.91	2.22
1986	12.9	12.3	5.9	0.7	7.0	22.8	26.8	3.18	2.46	19.86	0.74	2.36	1.82
1987	6.3	6.3	5.9	0.0	0.4	22.6	26.6	3.18	2.46	26.20	0.99	3.14	2.43
1988	11.0	10.3	6.0	0.8	5.1	22.8	26.8	3.18	2.46	21.76	0.81	2.58	2.00
1989	8.2	8.2	5.9	0.0	2.2	23.2	27.3	3.18	2.46	25.05	0.92	2.92	2.22
1990	6.5	4.9	5.9	1.6	0.6	22.6	26.6	3.18	2.46	26.00	0.98	3.11	2.41
1991	8.8	8.6	5.9	0.2	2.8	21.3	25.0	3.18	2.46	22.18	0.89	2.82	2.18
1992	10.8	10.7	6.0	0.1	4.8	21.6	25.4	3.18	2.46	20.59	0.81	2.58	1.99
1993	17.8	17.1	5.9	0.8	11.9	21.1	24.8	3.18	2.46	12.91	0.52	1.66	1.21
1994	8.9	8.0	5.9	1.0	3.0	21.9	25.8	3.18	2.46	22.78	0.88	2.81	2.18
1995	18.7	18.2	5.9	0.5	12.8	20.7	24.3	3.18	2.46	11.56	0.47	1.51	1.11
1996	14.2	12.9	6.0	1.3	8.2	22.2	26.1	3.18	2.46	17.88	0.69	2.18	1.69
1997	13.6	13.4	5.9	0.2	7.7	21.8	25.7	3.18	2.46	17.98	0.70	2.23	1.73
1998	26.0	22.1	5.9	4.0	20.1	20.4	24.0	3.18	2.46	3.93	0.16	0.52	0.40
1999	8.7	8.7	5.9	0.1	2.8	21.5	25.3	3.18	2.46	22.55	0.89	2.83	2.18
2000	11.5	11.2	6.0	0.3	5.5	22.4	26.3	3.18	2.46	20.77	0.79	2.51	1.99
2001	11.1	11.1	5.9	0.0	5.2	22.7	26.7	3.18	2.46	21.50	0.81	2.56	1.99
2002	7.6	7.6	5.9	0.1	1.7	22.3	26.3	3.18	2.46	24.62	0.94	2.98	2.31
2003	10.5	10.1	5.9	0.4	4.5	22.0	25.9	3.18	2.46	21.42	0.83	2.63	2.02
2004	9.8	9.6	6.0	0.2	3.8	22.5	26.5	3.18	2.46	22.65	0.86	2.72	2.11
2005	15.3	14.3	5.9	1.0	9.4	21.3	25.0	3.18	2.46	15.66	0.63	1.99	1.51
2006	12.1	11.3	5.9	0.8	6.2	24.7	29.1	3.18	2.46	22.92	0.79	2.51	1.99
2007	4.3	4.3	5.9	0.0	-1.6	23.7	27.9	3.18	2.46	29.51	1.06	3.36	2.62
2008	8.8	8.8	6.0	0.0	2.8	24.0	28.3	3.18	2.46	25.49	0.90	2.87	2.22
Median:	10.6	10.2	5.9	0.2	4.6	22.5	26.5	3.18	2.46	22.31	0.82	2.62	2.02
Max:	26.0	22.1	6.0	4.0	20.1	24.7	29.1	3.2	2.5	29.5	1.1	3.4	2.6
Min:	4.3	4.3	5.9	0.0	-1.7	20.4	24.0	3.2	2.5	3.9	0.2	0.5	0.4

Model Results – Dry Bean

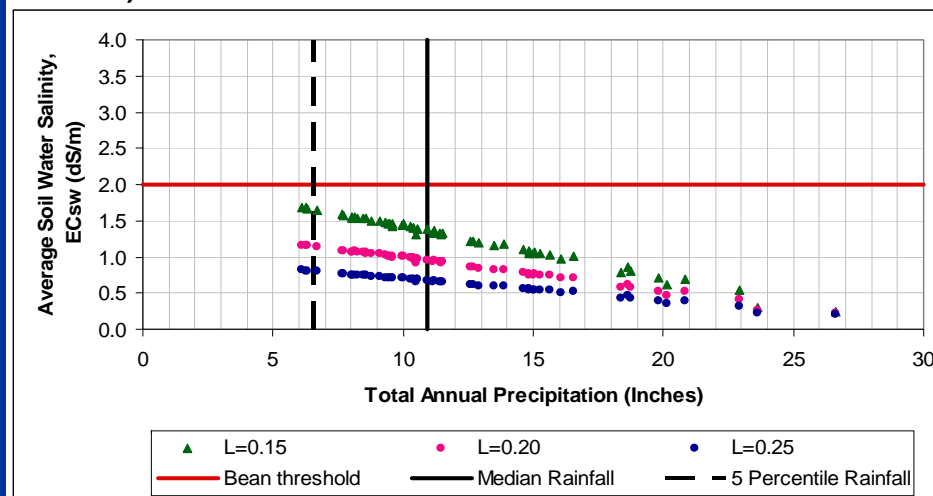
Irrigation Water = 0.7 dS/m

b) with exponential crop water uptake function*

b1) Crows Landing and Patterson



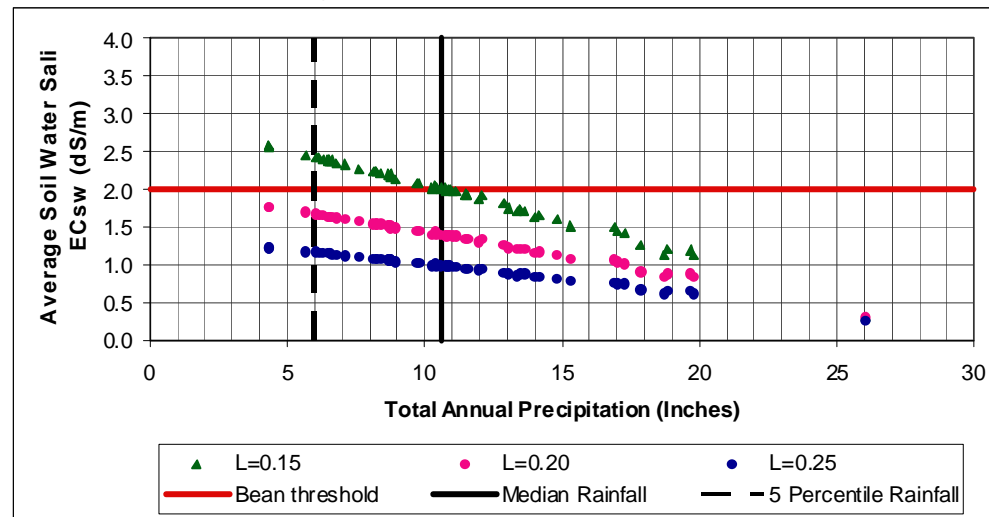
b2) Maze



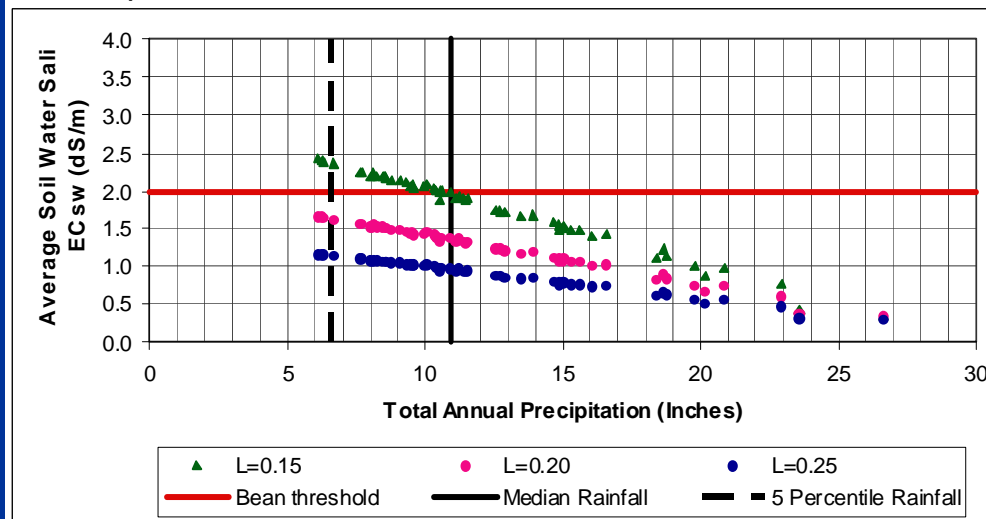
Model Results – Dry Bean

Irrigation Water = 1.0 dS/m

b1) Crows Landing and Patterson



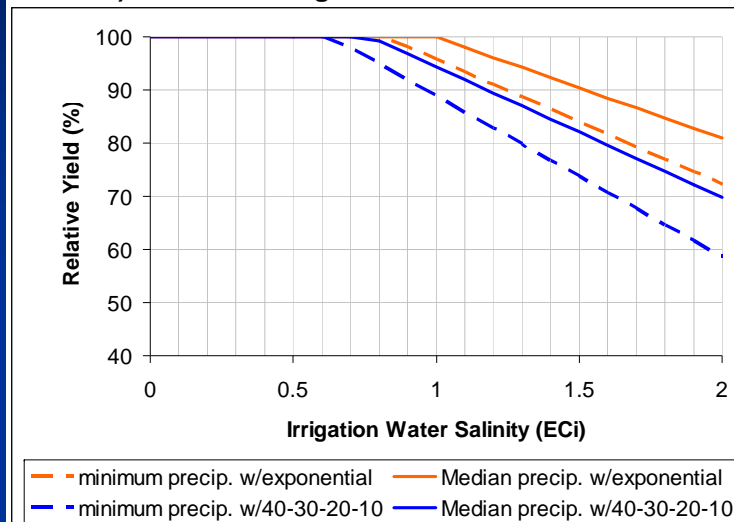
b2) Maze



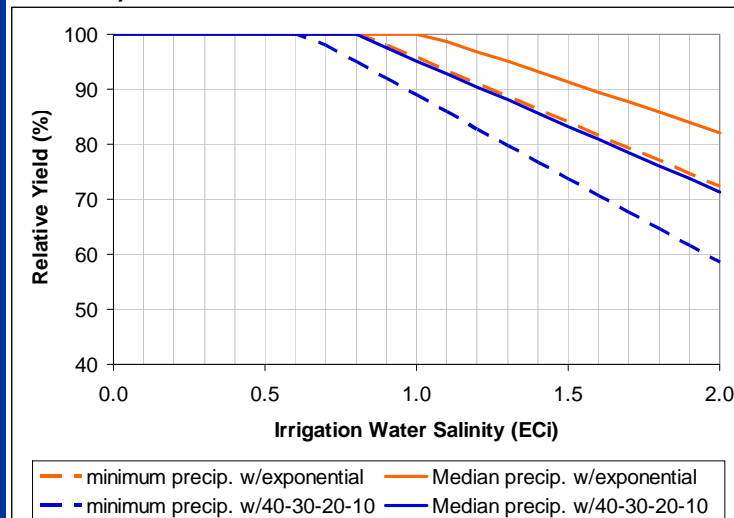
Model Results – Dry Bean

a) $L = 0.15$

a1) Crows Landing and Patterson



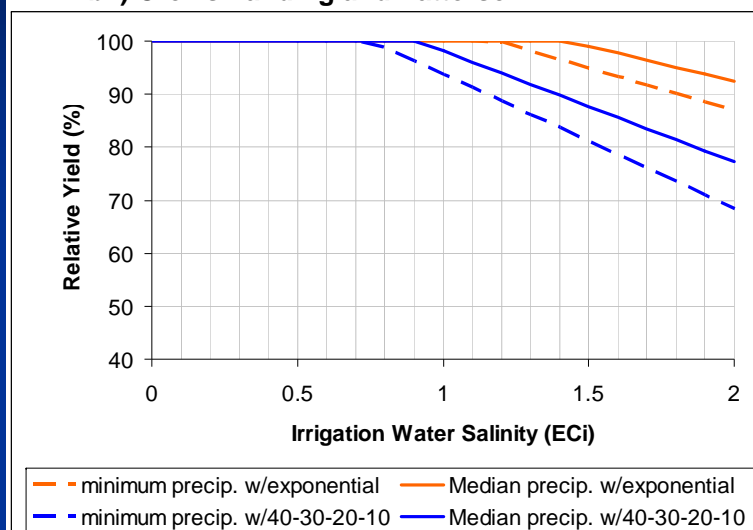
a2) Maze



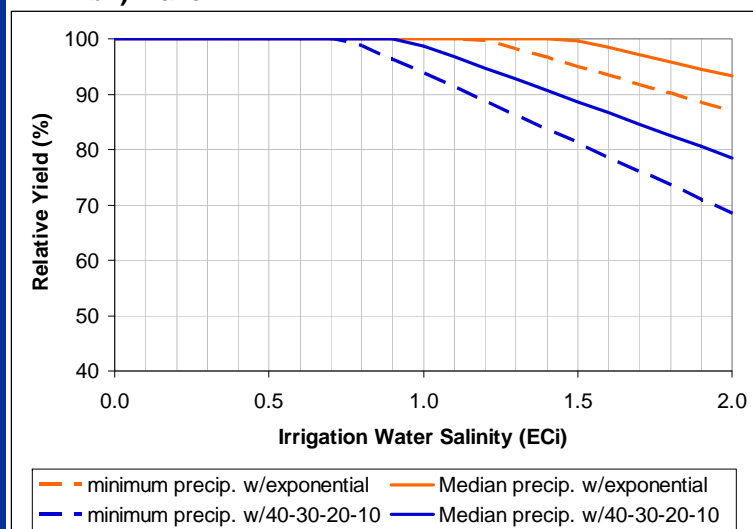
Model Results – Dry Bean

b) $L = 0.20$

b1) Crows Landing and Patterson



b2) Maze



Selected Model Results

Monitoring Site/LSJR Reach	Effective Precipitation Considered	Leaching Fraction (L)	Salinity Thresholds (EC _i) dS/m
BEAN (Most Salt Sensitive Crop in LSJR Irrigation Use Area)			
Crows Landing and Patterson (LSJR Tuolumne River to Merced River)	Median	0.15	1.0
	Minimum	0.15	0.8
	Median	0.20	1.4
	Minimum	0.20	1.2
Maze (LSJR Stanislaus River to Tuolumne River)	Median	0.15	1.0
	Minimum	0.15	0.8
	Median	0.20	1.5
	Minimum	0.20	1.2
ALMOND			
Crows Landing and Patterson (LSJR Tuolumne River to Merced River)	Median	0.15	1.4
	Minimum	0.15	1.2
Maze (LSJR Stanislaus River to Tuolumne River)	Median	0.15	1.5
	Minimum	0.15	1.2
ALFALFA			
Crows Landing and Patterson (LSJR Tuolumne River to Merced River)	Median	0.10	1.3
	Minimum	0.10	1.0
	Median	0.15	1.9
	Minimum	0.15	1.6
Maze (LSJR Stanislaus River to Tuolumne River)	Median	0.10	1.3
	Minimum	0.10	1.0
	Median	0.15	>2
	Minimum	0.15	1.6

Salt Tolerance of Crops in the Lower
San Joaquin River
(Stanislaus to Merced River Reaches)

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Secretary for Environmental Protection
Linda S. Adams

Central Valley Region
Preserve, enhance, and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.

- Executive Officer's Report
- Need Help?
- Do I Need a Permit?
- Dairy Program
- Enforcement
- Irrigated Lands Regulatory Program
- **Salinity (CV-SALTS)**
- Statewide Water Events
- Storm Water Toolbox
- Surface Water Ambient Monitoring
- **TMDLs and Impaired Water Bodies**
- Watershed Management Initiative
- Water Education
- Water Quality Goals
- More...

RESOURCES

- **Email Subscriptions**
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- Business Help
- Public Records Center

ANNOUNCEMENTS

- Welcome to Our New Website!
- Next Regional Board Meeting – 14 March 2008 in Rancho Cordova
- New Monitoring and Reporting Program for Irrigated Lands Coalition Groups
- Growers Assessed Penalties – Enforcement Stepped Up In Irrigated Lands Program
- California Water Plan Update – Get Involved!
- The State of the Central Valley Region – Executive Officer's Board Presentation

Salt Tolerance of Crops in the Lower
San Joaquin River
(Stanislaus to Merced River Reaches)

11 March 2010

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Comments on this Project

Please submit comments to:

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jsimi@waterboards.ca.gov

Comments must be received by 12:00 noon, 19 May 2010